# An Instrument for the Comparison of Thermometers



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## XII. *An Instrument for the Comparison of Thermometers.* *By* W. WATSON, *B.Sc., A.R.C.Sc., Assistant Professor of Physics at the Royal College of Science, London**.

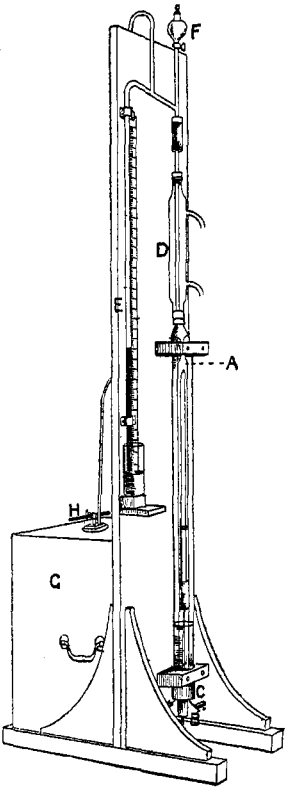
IN most investigations where it is necessary to measure temperature it is convenient to use a small thermometer, often of short range, particularly suited for the purpose. The only practicable method of determining the errors of such a thermometer is by comparing its readings with those of a standard thermometer. This comparison is in general rendered very difficult on account of the two thermometers differing both as to the length of the scale and the capacity of the bulb. Hence if, as is essential, the bulbs are placed close together in a water-bath, a considerable length of one of the mercury columns must be out of the bath, involving an uncertain correction for cool column. Again, the difference in size of the bulbs renders the lag of the thermometers different, so that unless the temperature of the bath is kept absolutely constant for some time we cannot be sure that *both* thermometers have reached a steady temperature. These objections make the use of a water-bath at temperatures over about 20° C. both troublesome and unsatisfactory, and this paper is written in order to describe an instrument which the author has designed for comparing some thermometers required for some other work, and which has worked so satisfactorily that it may be of some use to others.

The principle employed is that of using a vapour-jacket in order to obtain different constant temperatures, as recommended by Ramsay and Young (Journ. Chem. Soc. xlvii. p. 640, 1885). A general view of the instrument is shown in fig. 1. A glass tube AB, closed at the top and open below, about 76 cm. long and 2·5 cm. in diameter, passes up inside a second glass tube of about the same length and 4·7 cm. in diameter. The space between these two tubes is at the bottom closed by an indiarubber cork C (figs. 1 and 2), while at the top the inner tube is kept in place by three small pieces of glass rod fused on and forming a triradiate

* Read May 14, 1897.

star. The upper end of the outside tube is fused on to a Liebig condenser D, the upper end of the condenser being connected by a rubber joint fitted with a glycerine seal to a manometer E, a stoppered funnel F, and a large glass bottle which acts as a reservoir. This bottle is packed round with cotton-wool and is enclosed in a wooden box G. The air can be exhausted from or admitted to this bottle by means of a three-way tap H. Some mercury is placed on the top

Fig. 1.




of the cork C (fig. 2) to prevent the liquid used to form the vapour touching the cork. The liquid is heated by means of a spiral of fine uncovered platinum wire, the terminals being fused into glass tubes which pass down through the mercury and the cork.

Attempts to boil the liquid in an auxiliary bulb were rendered futile on account of the excessive bumping which took place after the liquid had been boiling for a day or two. The heating by a platinum wire, however, entirely obviates all bumping, and might be of use in determining the boiling-point or in distilling liquids which are inclined to bump, so long as they are not electrolytes.

Fig. 2.

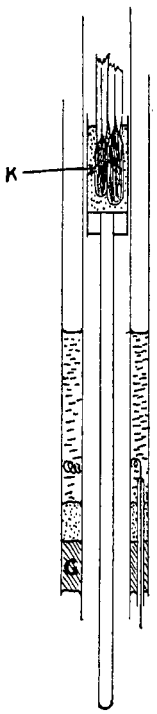
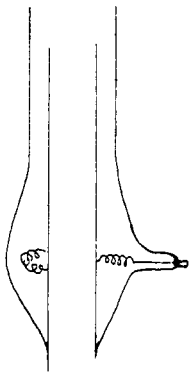



Fig. 3.



The vapour of the boiling liquid rises between the inside and outside tube, is condensed in the condenser D, and runs down to the bottom again.

The thermometers are fastened together, their bulbs resting in a small glass vessel K (fig. 2) which is filled with mercury. This vessel is supported by a glass rod which rests on the table on which the instrument stands. To remove the thermometers the instrument is drawn to the edge of the

table till this rod can be lowered and with it the thermometers. The scales are read by means of two telescopes, it being quite easy to see through the vapour if suitable liquids are used. The three liquids recommended by Ramsay and Young, viz. carbon bisulphide (20° to 46°), ethyl alcohol (46° to 79°), and chlorobenzene (79° to 120°) do very well. Water cannot be used as it forms drops on the inside of the glass so that the thermometers cannot be read. For temperatures higher than 120° the indiarubber cork closing the tube will not do, but the arrangement shown in fig. 3 may be used. The disadvantage of this form is that it can hardly be made by any but a professional glass-blower; the first form, on the other hand, can easily be put together by anyone who can do the most rudimentary glass-blowing.

In order that the indiarubber cork may form a thoroughly air-tight joint, it must be well cleaned with benzene, coated with indiarubber solution, and put in place while the solution is wet. When the solution has got thoroughly dry, which takes four or five days, the joint will be quite air-tight.

With such an arrangement the thermometers can easily be maintained at a temperature constant to within 0°·01 for three or four hours together. The manometer is only used to adjust the temperature to the desired point, a table of vapour-pressures being employed. In about half an hour after altering the pressure, and hence the temperature, the thermometer readings become quite constant. The instrument once started can be left entirely to itself; the only thing the observer has to do is to read the thermometers, then let a little more air in to get the next higher temperature. He may then go away for half an hour, and when he returns will find the temperature constant and can take the new readings.

## Discussion.

Prof. Ayrton thought the apparatus would come into extensive use; it did away with errors arising from differences of length of thermometer stems, it left no question as to the equality of temperature of the two bulbs, and there was no probability of error due to a difference of thermal "lag" in any two thermometers.

Mr. WATSON, in replying to a question of Prof. Perry's, said the fact of using indiarubber joints limited the available range of temperature. Working with blown joints, Ramsay and Young had found no difficulty in their vapour-density experiments at higher temperatures.

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## XIII. *On the Isothermals of Isopentane.*

*By* J. ROSE-INNES, *M.A.*, *B.Sc.**

[Plate IV.]

THE recent publication by Prof. Sydney Young of a long series of researches on isopentane (Proc. Phys. Soc. Session 1894–95, pp. 602–657) offers a great opportunity to those interested in the theory of gases. Since isopentane is a saturated hydrocarbon, there seems to be a reasonable hope that we are here dealing with a substance which will not tend to form complex molecules at low volumes, and whose behaviour may therefore be treated as normal; and this fact, together with the wide range of volume over which the experiments have been conducted, renders Prof. Young's results well fitted to test the various formulæ that have been from time to time proposed. Among these formulæ there is none more important than that formerly suggested by Prof. Young himself, in conjunction with Prof. Ramsay, that the pressure of a gas kept at constant volume is a linear function of the temperature; and the bearing of the experimental results with isopentane upon this formula is fully considered by Prof. Young in his paper. Accepting the formula, and writing it as

$$p = b\mathrm{T} - a,$$

where $b$ and $a$ are functions of the volume only, the values of $b$ and $a$ for a large number of volumes are given in the paper (*loc. cit.* pp. 650–655), and they are sufficiently numerous to enable us to fully test any algebraic expression that endeavours to represent them. I spent a considerable amount of time examining the values of $a$ and $b$, testing the formulæ that

* Read May 28, 1897.